Plasma response to a variable electric multipole configuration

N.K. Hicks¹, A.D. Bowman¹

¹Department of Physics & Astronomy, University of Alaska, Anchorage, USA

Charged particle traps are important tools for studying basic properties of atomic systems. Paul and Penning traps can confine small numbers of particles over long timescales. With increasing trapped particle density, space charge can degrade confinement. This study explores whether it is possible to improve on the space charge limit in a Paul trap-type device by neutralizing the charge. Two species, of opposite charge and with a mass disparity, are introduced into a radio frequency (RF) quadrupole structure. If conditions are such that the light species is stably trapped, the heavy species will be less affected by the trap RF. 3D particle-in-cell simulation (VSim 7, Tech-X Corp.) results are presented, investigating the details of the hypothesized effect. The scalings of the achievable trapping potential well with particle density and temperature, as well as with quadrupole trap parameters (frequency, voltage, and aperture size) are analyzed and discussed. Implications of these scalings for an experiment to explore the effect in the laboratory are presented. The effects of higher order multipole structures are also investigated, as well as the addition of an external magnetic field, and the formation and effect of the RF plasma sheath is discussed.

* Supported by U.S. NSF/DOE Partnership in Basic Plasma Science and Engineering Grant PHY-1619615